Environment and Natural Resources Trust Fund
2015 Request for Proposals (RFP)

Project Title: **ENRTF ID:** **028-A**

The Effect of Salt on Roadside Habitats

Category: A. Foundational Natural Resource Data and Information

Total Project Budget: $ 109,000

Proposed Project Time Period for the Funding Requested: 2 years, July 2015 – June 2017

Summary:

This research seeks to improve the conservation value of roadside habitats by understanding how road salt runoff impacts the nutrition and foraging behavior of herbivores (deer and butterflies).

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Sponsoring Organization: U of MN

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Location

Region: Statewide

County Name: Statewide

City / Township:

Alternate Text for Visual:

Preliminary data showing how salt runoff increases sodium levels in roadside plants, impacting herbivore development. A diagram of the experimental design for the proposed research.

_____ Funding Priorities	_____ Multiple Benefits	_____ Outcomes	_____ Knowledge Base
_____ Extent of Impact	_____ Innovation	_____ Scientific/Tech Basis	_____ Urgency
_____ Capacity Readiness	_____ Leverage		_____ TOTAL

PROJECT TITLE: The effect of salt on roadside habitats

I. PROJECT STATEMENT

The goal of this research is to determine how roadside salt runoff impacts the nutrition and foraging behavior of roadside herbivores. Minnesota has a million acres of roadside habitat that supports hundreds of species of plants and animals. However, much of this habitat is affected by road salt runoff – the Twin Cities alone applies approximately 350,000 tons of road salt to its roads each winter. While the negative impact of chloride in aquatic systems has been well studied, little research has considered the importance of sodium, which is less likely to enter waterways and more likely to affect roadside habitats. Sodium is a crucial micronutrient for animals, especially herbivores, and local concentrations of sodium are known to drive foraging behavior in a wide range of animals, from moose to ants. However, we know virtually nothing about the extent to which road salt application may affect animal nutrition and drive foraging behavior near roadsides. Preliminary data from the Snell-Rood lab shows that road salt runoff affects sodium availability in several kinds of roadside plants. This increased sodium availability can have positive effects on the development of muscle and neural tissue in roadside herbivores like monarch butterflies.

The proposed work will first conduct a more comprehensive survey of how road salt runoff impacts nutrition of animals feeding adjacent to the roads – Which types of plants are affected? Are effects more pronounced along major roadways? To what extent are effects attenuated over a season? Secondly, this research will address to what extent elevated sodium availability in roadside plants alters foraging behavior of key herbivores (butterflies and deer). Are animals being attracted to high sodium in roadside plants? To what extent to they learn to seek out roadsides for salt foraging? The outcomes of this research will have implications for road salt application methods in order to maximize the benefits of roadside habitats to animals of conservation concern such as monarchs and minimize the attraction of large mammals that may pose risks to drivers. This research will increase the conservation value of the million acres of roadside habitat in the state.

II. PROJECT ACTIVITIES AND OUTCOMES

Activity 1: Surveys of roadside nutrition **Budget: $40,000**

The first aim of this project is to quantify the effects of road salt runoff on nutritional value of roadside plants given variation in salt application across seasons, road types, and timing since salt application. We will survey five plant families of value to roadside herbivores such as deer and monarch caterpillars (legumes, milkweed, grasses, asters, and oaks). We will use inductively-coupled plasma atomic emission spectroscopy and the Dumas method to quantify percent sodium and nitrogen, respectively, in leaf samples. We will contrast three road types (state highway, county highway and suburban street, 4 replicate sites per type) across 3 time points in two seasons (N = 360 plant samples). We will additionally include prairie sites at Cedar Creek Long Term Ecological Research Station as a reference site.

Outcome	Completion Date
Measures of sodium levels across plants important to roadside herbivores	Fall 2016
Quantification of the effects of variation in road salt application on plant salt levels	Fall 2016

Activity 2: How roadsalt application alters foraging behavior of roadside herbivores **Budget: $69,000**

The second aim of this research seeks to determine how altered sodium nutrition of roadside plants affects foraging behavior of two herbivores, butterflies and deer. Are animals attracted to roadside plants with elevated sodium? To what extent to animals learn to associate elevated sodium levels with specific foraging locations (such as roadsides)? This aim focuses on butterflies and deer as two systems of concern for roadside habitats, in terms of their conservation value and also in terms of risks posed to drivers. In addition, by focusing on two diverse sets of animals, we can potentially make broader conclusions about how road salt runoff will

affect a wide range of wildlife species. Butterfly experiments will be performed in greenhouse and lab assays using both monarchs and cabbage white butterflies. We will measure oviposition preferences of female butterflies given a choice between plants that vary in sodium levels (based on the range of levels measured in the field in Aim 1). We can reliably manipulate sodium levels of plants in the lab through differential watering with dilute salt solutions. We will then perform a location-learning assay: in a large flight cage, we will pair high sodium plants with particular landmark cues (e.g., a chunk of asphalt). After a 1 day training period, on day 2 we will assay whether females prefer plants associated with the landmark cue, regardless of their sodium levels. Given previous associative learning experiments we've conducted in butterflies, we expect them to be fully capable of this task. An analogous set of experiments will be performed in the field using White-tailed deer. We will first manipulate sodium levels of potted plants preferred by deer. We will set out arrays of plants in fields at Cedar Creek Long Term Ecological Research Station. Using motion-sensor camera traps, we will measure feeding preferences of deer for plants with different salt levels (based on the range of values measured in Aim 1 from roadside plants). We will then perform an associative learning test, pairing high salt plants with different landmarks and landscape features in fields at Cedar Creek.

Outcome	Completion Date
Determination of levels of sodium in plants that attract or repel monarchs	Fall 2015
Determination of levels of sodium in plants that attract or deter deer	Summer 2016
Measurement of location learning in association with elevated sodium (in deer, monarchs)	Fall 2016

III. PROJECT STRATEGY

A. Project Team/Partners

All research will be carried out by University of Minnesota researchers. The project leader (Emilie Snell-Rood) will oversee sample collection and direction of experiments. ESR will direct plant sample collections with the help of an undergraduate research assistant. A graduate student (with the help of an undergraduate) will direct the foraging behavior experiments over the course of two summer and two academic year research assistantships. All plant samples will be processed at the University of Minnesota's Research Analytical Lab. All lab experiments (plant sodium manipulations and butterfly foraging behavior experiments) will be carried out in the University's Plant Growth Facilities. All field foraging experiments with deer will be carried out at the University's Cedar Creek Long Term Ecological Research Station. Funding for preliminary data for this project has been provided by the University of Minnesota (which will continue to provide space and IDC support).

B. Project Impact and Long-Term Strategy

This project represents the continuation of a University-funded project that began in 2011, focused on butterflies. The proposed plant surveys and foraging experiments would represent a one-time funding request from LCCMR. The proposed work is expected to result in at least three scientific publications and a number of presentations at national and local meetings. The researchers will communicate the results with Minnesota-based agencies (DNR and MnDot) for which the results are directly applicable. The results are expected to have immediate implications for road salt applications in Minnesota – are our current levels attracting deer to roadsides? Do certain levels of salt application actually affect the growth of species like monarchs? This project represents a specific component of the main research program of the Snell-Rood lab, which investigates how animals respond to human environments. Much of the basic research in the lab is funded by NSF and NIH.

C. Timeline Requirements

The proposed research will take 24 months. This project requires two field seasons (summer 2015 and summer 2016) for conducting plant surveys and foraging experiments. Foraging experiments will continue into the fall of both 2015 and 2016. Early 2017 will be used to analyze field data (e.g., from camera traps) and write up results.

2015 Detailed Project Budget

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IV. TOTAL ENRTF REQUEST BUDGET 2 years

BUDGET ITEM	AMOUNT
Personnel: Emilie Snell-Rood (PI) - 1 summer month in years 1 & 2 (75% salary, 25% fringe) - The PI is on a 9-month appointment at the University of Minnesota. She requests 1 month of summer salary for each of the 2 years of the project. The majority of the rearing experiments and sample collection will occur during the summer months – thus, the PI will be spend much of the summer months on this project.	$ 25,000
Graduate Student - 50% time for one semester plus summer for years 1 &2 (61% salary, 39% fringe) - The experiments will be run by graduate students, working on summer and academic year research assistantships (1 RA per summer, 1 RA per academic year).	$ 58,000
Undergraduate Students - 2% time for four students (93% salary, 7% fringe) - An undergraduate assistant will help during the summer months with sample collection, butterfly rearing and field work at cedar creek.	$ 4,000
Equipment/Tools/Supplies: Supplies - A variety of materials and supplies are needed to grow plants for the plant manipulation experiments, and rear and maintain butterflies for the foraging behavior experiment. Motion-detection camera "traps" will also be used in the deer foraging experiment ($150/camera, 30 cameras needed).	$ 8,000
Travel: Funds are requested for travel to sites for plant sample collection (both summers) and Cedar Creek LTER for deer observations (the second summer).	$ 3,000
Additional Budget Items: Analyses - Plant processing costs. Aim 1 of this grant includes nitrogen and sodium quantification in for 360 plant samples. These analyses will be run at the Research Analytical Labs (University of Minnesota). Given their current rates, the total cost to run these samples is $9000, spread over the two years of the grant.	$ 9,000
Greenhouse facility charges: Greenhouse space is necessary to raise plants (for experiments in both summers) and conduct butterfly behavioral assays. The University of Minnesota charges for use of such greenhouse space, roughly $100-200/month for the space we use for butterflies and plants. We expect these experiments will run approximately 6 months each year.	$ 2,000
TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND $ REQUEST =	$ 109,000

V. OTHER FUNDS

SOURCE OF FUNDS	AMOUNT	Status
Other Non-State $ To Be Applied To Project During Project Period.	$0	*NA*
Other State $ To Be Applied To Project During Project Period.	$0	*NA*
In-kind Services To Be Applied To Project During Project Period: *Facilities and Administrative Costs from University of Minnesota (52% MTDC of project budget)*	$46,000	*Secured*
Funding History: *Funds supplied from the Office of the Vice President for Research (University of Minnesota) that funded this project during its first two years (spent by 2013).*	$28,000	Secured
Remaining $ From Current ENRTF Appropriation.	$0	*NA*

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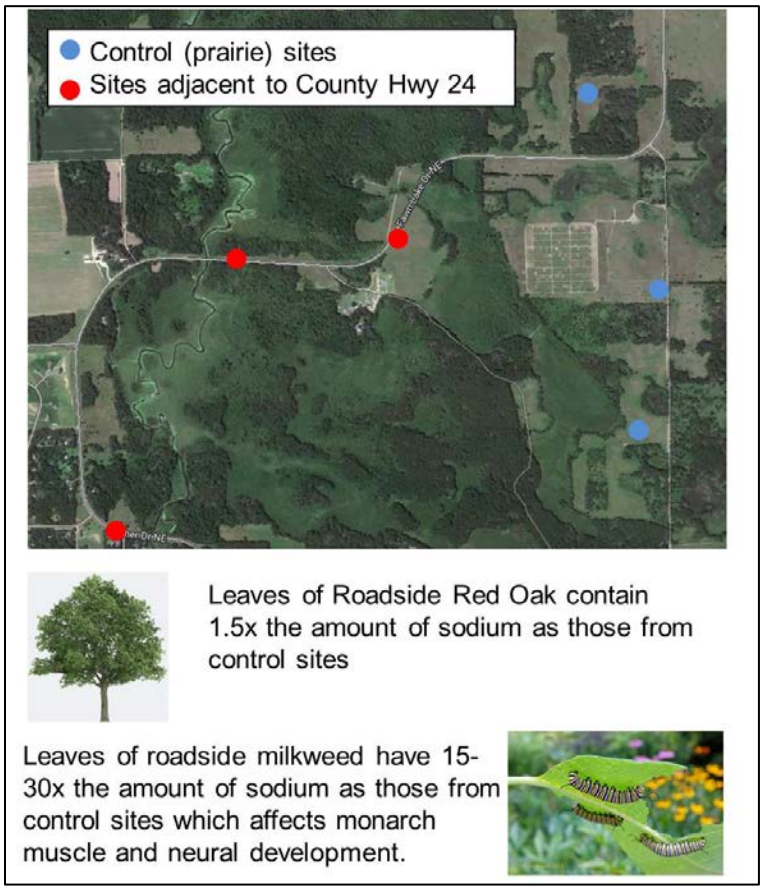
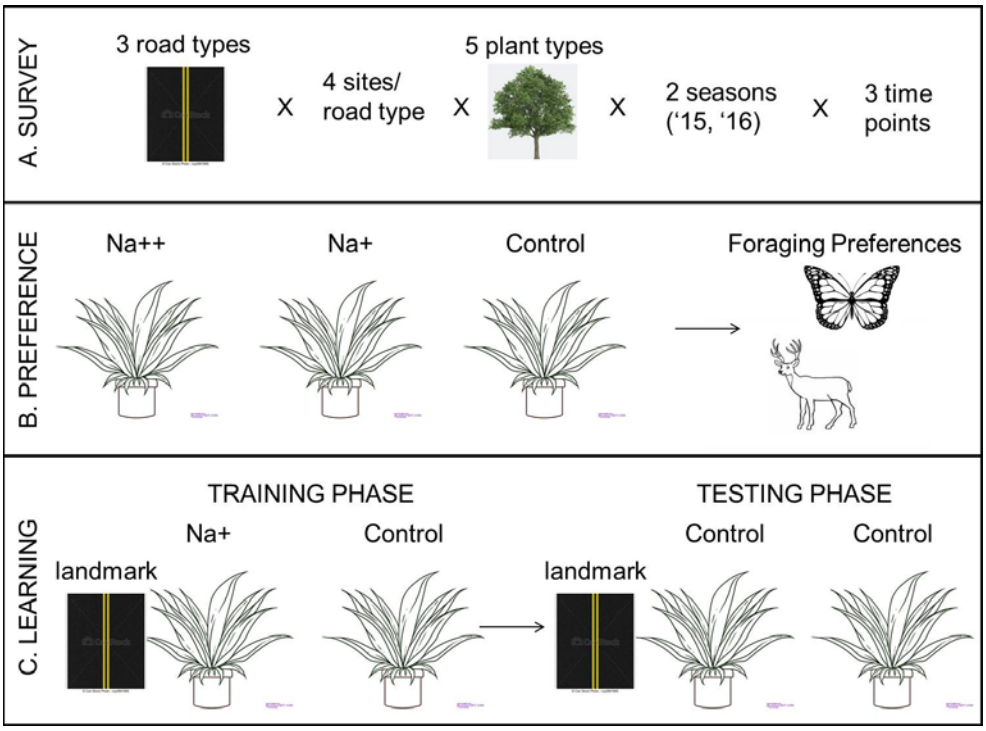
PRELIMINARY DATA



EXPERIMENTAL PLAN



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Project Manager Qualifications

Emilie Snell-Rood is an Assistant professor at the University of Minnesota with expertise in ecology, animal behavior and evolutionary biology. She has published a range of publications (>25 papers) that consider how animals respond to environmental change, through adjustments in their behavior or development. Additional specific qualifications with regards to this project:

- Experience with butterfly rearing (>15,000 individuals) and behavioral experiments
- Experience with measurement of vertebrate morphology and behavior in both the lab and the field (both mammals and birds)
- Expertise in the design and interpretation of animal learning experiments (both associative and motor learning, particularly in insects, but also in vertebrates)
- Experience mentoring graduate and undergraduate students on projects of similar scope
- Experience identifying plants and collecting leaves for nutrient analysis (>200 specimens for a separate project)
- Experience presenting research results to the public in outreach events at national meetings and the Minnesota State Fair

Publications most closely related to the proposed research:

- Snell-Rood, EC, A Espeset, C Boser, W White, R Smykalski. Anthropogenic changes in sodium affect neural and muscle development in butterflies. In revision, PNAS.
- Snell-Rood, E. C., and N. Wick. 2013. Anthropogenic environments exert variable selection on cranial capacity in mammals. Proceedings of the Royal Society of London B 280: 1471-2954. doi: 10.1098/rspb.2013.138413.
- Snell-Rood, E. C., G. Davidowitz, and D. R. Papaj. 2011. Reproductive tradeoffs of learning in a butterfly. Behavioral Ecology 22: 291-302. 19.
- Snell-Rood, E. C., D. R. Papaj, and W. Gronenberg. 2009. Brain size: a global or induced cost of learning? Brain, Behavior and Evolution. 73:111–128.
- Snell-Rood, E. C., E. Swanson, A. Espeset, R. Kulhanek, I. Mikati, R. Smykalski, I. Bolduc, N. Eichten, S. Khare, W. A. White and S. Kenzie. Nutrient availability constrains the evolution of life history traits: a comparative study across butterflies. In prep.

Organization Description

Mission statement, from the University of Minnesota's website (http://www1.umn.edu/twincities/history-mission/):

"The University of Minnesota, founded in the belief that all people are enriched by understanding, is dedicated to the advancement of learning and the search for truth; to the sharing of this knowledge through education for a diverse community; and to the application of this knowledge to benefit the people of the state, the nation, and the world. The University's mission, carried out on multiple campuses and throughout the state, is threefold: research and discovery, teaching and learning, and outreach and public service."